his "Entomological Fauna of Oceanica," has formed on the same insect his genus *Heteroscelis*; and Mr. Westwood, in his "Arcana Entomologica," changed that name, already employed for a genus of *Hemiptera*, and called it *Campylocnemis*, in allusion to the singular character of the hind tibiæ, namely, that of being curved.

Castlenau's generic name, being the oldest, should be retained; and I therefore introduce it to you this evening as the *Hyperion Schrœtteri.*

The Count tells me this insect is very rare in collections. It has been figured by Schrebers, Castlenau, and Westwood. The few specimens previously known were from the eastern parts of New South Wales. Both Count Castlenau and Dr. Godfrey Howitt consider the discovery of this insect in Victoria as a zoological fact of considerable interest, especially as, by its size and remarkable form, it belongs to a tropical fauna.

I trust, that, now it is known to exist in this country, many will be on the look-out for it. It has considerable pecuniary value, and can always be exchanged for first-class specimens of other *Coleoptera* in any part of the world.

ART. XXIX.—*Surface and Underground Drainage of Melbourne.* By ALEXANDER K. SMITH, Esq., C.E., F.R.S.S.A., &c.

[Read 16th May, 1864.]

In bringing this subject before the Royal Society, I at once admit that, though the Surface Drainage is of less importance to the inhabitants of Melbourne than the Underground Sewerage, at the same time the information contained in this paper will materially assist the proper consideration of the best mode to be adopted in carrying out the latter at the least expense.

The chief objections to the present open drains or channels in the streets are, first: That they become the recipients of the sewage from houses, the overflow of cesspools, &c., which they convey through the public streets, and in the largest quantity where the population is most dense, and the traffic greatest, to the prejudice of the comfort and health of the inhabitants.

The second objection is, that the street channels, especially in Elizabeth and Swanston-streets, are filled to overflowing during sudden and heavy rains; flooding the streets, interfering with public traffic and private business, destroying property, and causing vast and often-recurring expense to the corporation in re-metalling portions of the streets, and in removing the deposits of mud, sand, road metal, &c., caused by these sudden inundations.

The first of these objections can only be remedied by underground drainage, and the second by intercepting the storm waters before they enter the city so far as to occasion loss of property or inconvenience to business, and it is to this portion of the subject that I especially direct attention in this paper.

Any one at all acquainted with Melbourne will be aware that the outlets for the surface water are the open street sewers; on the south, crossing Flinders-street at right angles, at Russell-street, Swanston-street, Elizabeth-street, Market-street, and King-street; and at Little Bourke-street on the west: and my principal object in this paper is to show the relative amount of water carried off at each outlet, the area it drains, and to suggest a plan for preventing floods in the principal business parts of the city.

Ten years ago it seemed to me not only desirable, but essentially necessary, to prevent the various floods that occurred in Elizabeth and Swanston-streets, by intercepting the waters at the north boundary of the city, and conveying them by means of a tunnel into Batman's Swamp. Subsequently, I brought the subject before the Philosophical Institute, in a paper read before that Society on the 4th March, 1857, and in another paper "On the Reclamation of Batman's Swamp," read before the Philosophical Institute on the 5th May, 1858, and published in Vol. III. of their Transactions.

I now bring this suggestion again forward in a more practical shape, and to determine how far it would answer its intended purpose, I have made a survey of the entire area drained by the open channels to the south and west of the city, avoiding any particular reference to the main channels that carry off the storm water falling upon the various suburbs, except so far as those that pass through the city itself.

The proper consideration of this subject renders it necessary to ascertain, as accurately as possible, the amount of rain that falls during the year, and more particularly the maximum quantity that has fallen in any given time, as it will be obvious that any underground sewer made to carry off the surface water must be of sufficient size to receive and discharge the largest quantity that has been known to fall in a given time, together with the ordinary waste water from the Yan Yean supply.

The following tables, compiled from the records at the Government Observatory, supply ample information relative to the rainfall during seventeen years, and which is of special value when brought to bear upon the subject now before us. In short, without some reliable data of this kind to guide us, any system of storm-water drainage would be merely a matter of opinion on which engineers might disagree.

TABLE A.

This Table shows the amount of rain falling in Melbourne each year from 1840 to 1850, and from 1855 to 1860, inclusive, and shows also the difference in the amount each year, from the mean rainfall during 17 years.

	Amount in Inches.	Difference of Amount of each Year, and mean rainfall for 17 Years.
1840	22·57	— 5·83
1841	30·18	+ 1·78
1842	31·16	+ 2·76
1843	21·54	— 6·86
1844	28·26	— 0·14
1845	23·93	— 4·47
1846	30·53	+ 2·13
1847	30·18	+ 1·78
1848	33·15	+ 4·75
1849	44·25	+ 15·85
1850	26·98	— 1·42
1855	28·21	— 0·19
1856	29·75	+ 1·35
1857	28·90	+ 0·50
1858	26·02	— 2·38
1959	21·80	— 6·60
1860	25·40	— 3·00

Mean rainfall for 17 years, 28·40.

The greatest difference in rainfall for the above period amounts to 22·71 inches. The average rainfall for the last six years—from 1855 to 1860, viz., 26·679 inches, differs but slightly from the average fall of rain for any six consecutive years from 1840 to 1848, including the abnormal rainfall in 1849.

TABLE B.

This Table gives a comparative statement of the average rainfall during the spring, summer, autumn, and winter seasons of the years 1840 to 1850, and 1855 to 1860-1.

Quarters.	1840 to 1850.	1855 to 1860-1,
Spring	9·15	7·90
Summer	5·34	7·86
Autumn	7·65	6·46
Winter	7·02	4·94

In both periods the fall in spring is the greatest, but there is a marked increase in the average rainfall during summer in the last period on that during the years 1840 to 1850, while, on the other hand, there is a decrease in amount in the remaining quarters.

TABLE C.

This Table is a statement of the maximum amount and duration of rain that fell on different dates from 1855 to 1861.

1855	Dec. 29	0·92 inches	2½ hours.
1856	Sept. 23	0·92 „	Thunder storm, 20 minutes.
1857	Feb. 10	3·42 „	7 p.m., to evening of 11th.
1858	Dec. 19	1·623 „	During the afternoon.
1859	June 8	0·616 „	Thunder storm.
1860	Dec. 9	2·586 „	20 hours.
1861	Jan. 31	2·37 „	11 hours.

TABLE D.

This Table shows the amount of rain that fell in each month during six years, being from 1858 to 1863, inclusive, and also shows the average per month for six years, and the maximum amount that fell in 24 hours, in every month during the same period.

Months.	1858.	1859.	1860.	1861.	1862.	1863.	Average.	Maximum in 24 hours during six years.	
Jan.	0·880	2·864	1·974	2·246	1·253	1·838	1·843	1·288	26th, 1859
Feb.	4·910	0·828	1·075	4·618	0·187	2·741	2·393	2·436	1st, 1861
March	1·090	0·177	0·963	2·649	1.082	3·839	1·633	2·158	19th, 1861
April	0·599	1·288	4·525	1·288	3·558	1·758	2·169	1·916	5th, 1860
May	1·384	2·324	0·995	0·836	4·307	2·545	2·065	0·860	8th, 1862
June	0·761	4·510	1·716	1·780	2·988	1·161	2·153	1·170	27th, 1859
July	2·072	1·037	1·206	2·138	2·262	2·872	1·931	0·557	12th, 1858
August	1·615	0·952	0·793	1·470	1·954	2·102	1·481	0·664	2nd, 1862
Sept.	2·171	2·773	2·724	3·190	0·976	1·990	2·304	1·072	10th, 1861
Oct.	0·869	2·335	1·971	4·888	2.031	4·891	2·831	1·393	4th, 1861
Nov.	3·192	1·712	2·379	1·459	0·317	3·509	2·095	1·203	26th, 1863
Dec.	6·473	1·025	5·062	2·584	1·165	7·182	3·915	2·359	9th, 1860

TABLE E.

This Table shows the maximum amount that fell in each month in each year from 1858 to 1863, inclusive.

	1858.	1859.	1860.	1861.	1862.	1863.
January	... ...	1·288 26th	0·736 8th	0·597 16th	0·738 16th	0·553 14th
February	... ...	0.248 9th	0·043 19th	2·436 Jan. 31	0·087 12th	1·007 17th
March	... ...	0·105 22nd	0·727 17th	2·158 19th	0·715 6th	1·036 16th
April	2·031 28th	0·452 13th	1·916 5th	0·416 16th	1·087 17th	0·746 24th
May	0·484 6th	0·460 12th	0·280 23rd	0·156 3rd	0·860 8th	0·672 20th
June	0·075 27th	1·170 27th	0·328 23rd	0·375 1st	0·776 1st	0·556 6th
July	0·557 12th	0·305 12th	0·290 27th	0·370 18th	0·440 24th	0·384 7th
August	0·431 11th	0·273 7th	0·422 23rd	0·249 22nd	0·664 2nd	0·240 19th
September... ...	0·488 11th	0·637 15th	0·556 8th	1·072 10th	0·194 8th	0·416 22nd
October	0·494 20th	0·534 27th	0·788 8th	1·393 4th	0·989 28th	1·125 13th
November... ...	0·949 30th	0·741 25th	0·647 23rd	0·373 30th	0·161 14th	1·203 26th
December... ...	1·623 19th	0·299 17th	2·359 9th	0·681 2nd	0·592 8th	1·847 14th

TABLE F.

This Table gives the date, duration, and amount of extraordinarily heavy rains that fell in 1859—60—61—62—63, and to the present date in 1864.

1859.

Date.	Quantity.	Duration of Rainfall.
January 9	0·567	During a thunderstorm in 1 hour 39 minutes.
,, 18	0·181	Between 2 and 3 hours, a.m.
,, 26	0·481	During a thunderstorm in 1 hour 42 minutes.
	1·184	Amount of rain on this day in 8 hours 9 minutes.

Date.	Quantity.	Duration of Rainfall.
May 15	0·428	During 1 hour and 15 minutes.
,, 29	0·161	,, Thunderstorm, lasting ½ hour.
June 8	0·683	,, ,, ,, 1½ hours.
,, 13	0·230	,, ,, ,, 1 hour 6 minutes.
,, 14	0·570	,, ,, ,, 1 hour.
,, 27	0·437	,, ,, ,, 3 hours.
	1·170	Being the whole amount during this day.
Nov. 2	0·557	During 2½ hours.
,, 25	0·668	,, 3 hours 50 minutes.

1860.

Date.	Quantity.	Duration of Rainfall.
January 7	0·542	During a thunderstorm, lasting 3½ hours.
March 17	0·727	,, 8½ hours.
April 5	0·850	,, 4 hours.
	2·519	The rain of this and preceding day, 33 hours.
,, 22	0·474	During 3 hours.
	1·005	The whole amount of rain on this and the following day during 20 hours.
August 22	0·353	During 2 hours.
Sept. 8	0·500	,, a heavy thunderstorm, between 5 and 6 p.m.
,, 20	0·352	During 2 hours 20 minutes.
Oct. 10	0·263	,, 1½ hours.
Nov. 11	0·132	,, ½ hour.
,, 23	0·601	,, Thunderstorm lasting 2 hours.
Dec. 9	1·693	,, ,, within 7 hours.
	3·320	Being the whole amount of rain on this and following day, during 42 hours.

1861.

Date.	Quantity.	Duration of Rainfall.
January 16	0·869	During a thunderstorm in 7 hours.
,, 31	2·370	,, 11 hours, with thunderstorm overhead.
	3·286	The whole amount of rain on this and the following day, during 33 hours.
Feb. 14	0·376	During a thunderstorm of 2½ hours duration.
March 19	1·004	,, 3 hours.
	2·158	Being the whole amount on this day, during 21 hours.
,, 20	0·246	A heavy shower, lasting 40 minutes.
April 16	0·416	During 3 hours 15 minutes.
Sept. 10	1·072	,, 11½ hours.
October 2	0·269	,, a thunderstorm of 1 hour 30 minutes.
,, 4	0·754	,, ,, ,, 3 hours.
	1·592	Amount on this day, during 12½ hours.

Date.	Quantity.	Duration of Rainfall.
October 10	1·118	On this and 2 following days, during 15 hours.
,, 24	0·661	During a heavy thunderstorm, in 3½ hours.
,, 28	0·843	,, 7 hours.
Dec. 2 & 3	1·207	,, 17½ hours.
,, 22	0·773	,, 7 hours.
Jan. 16	0·720	,, 5 hours.
,, 21	0·435	,, a thunderstorm, within 3½ hours.
March 6	0·715	,, ,, ,, 6½ hours.
April 16	0·758	,, 6 hours.
,, 17	0·522	,, 5 hours.
,, 18	0·532	,, 2 hours and 5 minutes.
	2·792	The rain on these last 3 days, during 37 hours.
May 5	1·234	Till noon on the following day, during 17 hours.
,, 8	0·332	During 2 hours.
	1·411	Amount of rain till 6 a.m. on the following day, in 22 hours.
June 1	0·776	During 7½ hours.
July 23	0·227	,, 1 hour.
October 23	0·242	Within 40 minutes.
,, 27	0·476	During a thunderstorm, within 1 hour.
,, 28	0·513	,, 4 hours 20 minutes.
Dec. 8	0·478	,, a thunderstorm, within 25 minutes.
		1863.
January 13	0·491	During a thunderstorm, in 2 hours.
February 3	0·254	,, ,, ,, within 40 minutes.
,, 17	1·007	,, ,, ,, ,, 23 hours.
March 16	1·036	,, ,, ,, ,, 8 hours.
,, 18	0·800	,, the afternoon.
April 24	0·746	,, 5 hours.
May 14	0·380	,, 4 hours.
June 6	0·438	,, ,,
July 27	0·111	About 5 minutes, with hail.
August 2	0·664	During about 6 hours.
Sept. 1	0·261	,, the afternoon and part of the evening.
October 13	1·125	,, 24 hours, with short intermissions.
,, 17	0·752	,, the afternoon and evening.
Nov. 22	0·964	,, the afternoon.
,, 26	1·203	,, 14 hours.
December 6	1·105	Between 8 and 9 a.m.
	5·196	On the 13th, 14th, 15th, and 16th.
,, 30	0.418	During 2 hours.

1864.

Date.		Quantity.	Duration of Rainfall.
January	9	0·839	During the afternoon, and till 9 p.m.
,,	19	0·569	Between 3 and 9 p.m.
February	7	0·724	During 5 hours.
,,	18	0·500	,, a thunderstorm, in 1 hour.
March	2	1·180	,, ,, lasting ½ hour.
April	1	1·095	From 9 p.m. to 9 a.m. on the 2nd, rain showers at intervals.
,,	15	0·283	During one hour.
,,	24	0·511	,, 4 hours.

Referring then to Table A, we find that the mean rainfall in Melbourne for 17 years amounts to 28·40 inches.

The minimum quantity fell in 1843, viz., 21·54 inches, and the maximum in 1849, viz., 44·25 inches.

From Table B we find that the greatest quantity falls in the spring, and the least in the winter season.

In Table C we find that on the 23rd September, 1856, 0·92 inches fell during a thunderstorm in 20 minutes.*

In Table D we find that the greatest quantity that fell in any month during the six years was 7·182 inches in December, 1863, and the greatest quantity in any one day was 2·436 inches on the 31st January, 1861. (See also Table E.)

In Table F we find that 1·180 inches fell during 30 minutes on the 2nd March, 1864.

TABLE G.

The following Table shows the several areas drained by outlets A, B, C, D, and E, their locality, and the mean amount of rain in gallons and tons that falls annually on these respective areas.

Outlet.	Situation.	Area in Acres.	Imperial Gallons.	Weight in Tons.
A.	Falling into the river Yarra below the falls at Market-street	530·35	340,731,206	1,521,121
B.	Falling into the Yarra above the falls at Prince's Bridge	248·2	159,459,763	711,874
C.	Falling into a culvert running under the Government Railway Station at the west end of Little Bourke-street, and subsequently into Batman's Swamp	98	62,961,550	281,078

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* The heaviest rainfall known during the time the records have been kept in Victoria.

Outlet.	Situation.	Area in Acres.	Imperial Gallons.	Weight in Tons.
D.	Falling into the Yarra at the south end of King-street, near Cole's Wharf	53	34,050,634	152,012
E.	Falling into a culvert passing under the Melbourne Railway Station at the south end of Russell-street, and subsequently into the Yarra	27·5	17,667,782	78,874
	Totals ...	957·05	614,870,935	2,744,959

The abnormal quantity of rain that fell in 1849 upon the same area was nearly 56 per cent. more than the quantities here stated, the total quantity in that year being 958,029,539 gallons, being the greatest quantity that has fallen in any one year since correct meteorological records were kept in Victoria.

The Elizabeth-street sewer, marked A, has its source (as will be seen upon the plan now submitted) on the roadway between the north end of the University grounds and the new Cemetery, at a distance of two miles and 15 chains (along its course) from the point where it discharges into the Yarra Yarra below the falls, the entire area drained by this channel being 530·35 acres.

The area drained by the channel in Swanston-street, marked B, is 248·2 acres. The source of supply at the greatest distance from the outlet is at a point in Lygon-street, between Grattan and Faraday-streets, 1½ mile from the point at which it falls into the Yarra at Prince's Bridge.

The area drained by the channel marked C at the west end of Little Bourke-street, receives the drainage of 98 acres; the greatest length traversed being 58 chains.

The water from this channel is discharged into a circular sewer built of brick, 3 feet 3 inches in internal diameter, and passes underneath the station ground of the Victorian Railways into Batman's Swamp. This culvert is now being considerably lengthened, in order to convey the water under the new station ground made by the removal of Batman's Hill. On account of Spencer-street being sometimes flooded, it has given rise to an erroneous impression that the culvert is too small to carry off the water, but the real reason is, that the grating at the mouth has frequently been partially closed, and the whole storm-water not being able to enter, it, as a matter of course, soon covered the street. This can easily be obviated by making the grating longer, with the bars lying in the direction of the stream, the force of which would keep the grating clear.

This culvert, from its size and inclination, is sufficient to carry off the water of the heaviest thunderstorm recorded.

The channel marked D, at the south end of King-street, drains 53 acres, and the channel marked E, at the south end of Russell-street, 27½ acres; giving a total area of 957·05 acres drained by the five outlets A, B, C, D, and E.

These channels have also another source of supply beside the rains, namely, the waste water or ordinary sewage from houses, cellars, shops, yards, baths, wash-houses, dye-houses, water engines, manufactories, urinals, the overflow of cesspools, stables, fountains, street-watering, &c.

To determine the amount of water flowing in the street channels from these sources, I have made a series of experiments at the outlets B and E, the respective areas drained by them being 248·2 and 27·5 acres.

The first experiments were made at the outlet E, near the Duke of Wellington Hotel, Russell-street and Flinders-street, and the results, from actual measurement, gave a mean result of 43·3 gallons per minute.*

The next experiments were made at the mouth of the stone culvert crossing Flinders-street at the end of Swanston-street, and the mean results of the various measurements gave 397½ gallons per minute.

The measurements in both cases were made at periods when no rain had fallen within 48 hours; the streets and ground being dry, and the channels uninfluenced by rain.

The discharge at B and E gave respectively 1·561 and 1·574 gallons per acre per minute; quantities approximating so closely to each other that it was only after repeatedly checking the measurements and calculations that I was satisfied of their being correct.

The quantity of sewage or waste water discharged at the outlets B and E, according to the experiments, is at the rate of 203,670,000 and 22,758,480 gallons per annum, and by applying the mean of the two measurements to the areas drained by the other outlets, we have in Table H the total quantity of rain and sewage discharged by each outlet per annum.

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* The water was measured in a rectangular cistern, accurately made measuring 72 x 19 x 5 9-16ths = 4005 cubit inches, which was filled in 20 seconds.

TABLE H.

Outlet.	Area in Acres.	Mean Amount of Annual Rainfall in Gallons.	Mean Annual Sewage in Gallons.
A.	530·35	340,731,206	436,943,697
B.	248·20	159,459,763	203,670,000
C.	98·00	62,961,550	80,740,044
D.	53·00	34,050,634	43,665,534
E.	27·50	17,667,782	22,758,480
Total ...	957·05	614,870,935	787,777,755

614,870,935 Rainfall
787,777,755 Sewage

1,402,648,690 Grand Total.

However, to determine the quantity of water discharged at the various outlets during the heaviest rain fall in a given time, we must refer back to Table C, where it will be found that on the 23rd September, 1856, 0·92 inches fell during a thunder-storm in twenty minutes. Upon this data, then, we can determine the maximum rate per hour discharged at these outlets, and thus be enabled to determine the size of any sewer or culvert necessary to carry off the storm waters from the city, by intercepting them at the intersection of Stephen and Lonsdale-streets, and of Elizabeth and Latrobe-streets.

Table I. will shew the amount of sewage and storm water discharged in twenty minutes. The sewage being the ordinary waste water before alluded to, and the rain water being that which fell as before recorded. It will also show the rate per hour from both sources.

TABLE I.

Outlet.	Sewage.	Rainfall.	Total.	Total per hour.
A.	16·626	11,037,771	11,054,397	33,163,191
B.	7·750	5,165,597	5,173,347	15,520,041
C.	3·072	2,039,599	2,042,671	6,128,013
D.	1·661	1,103,048	1,104,709	3,314,127
E.	866	572,336	573,202	1,719,606
Total	29·975	19,918,351	19,948,326	59,844,978

From this table it will be seen that at outlet A the water discharged during that storm was at the rate of 33,163,191 gallons per hour, and the water discharged at outlet B was at the rate of 15,520,041 gallons per hour.

These enormous volumes of water, principally falling outside the City, pass, on their way to the Yarra, through the very busiest of our streets, namely, Elizabeth and Swanston-streets, and flood the same to such an extent as to prevent traffic of any description.

The size of the open channels in Swanston-street, and the contour of that street, will not admit of the channels carrying off the whole of the water, and from its being higher than Elizabeth-street, a very large amount of water overflows down Bourke-street, Little Collins, and Collins-streets into Elizabeth-street, augmenting the flood in that street to such an extent as to make it dangerous alike to life and property, irrespective of the great damage done to the streets themselves.

The question now comes before us, by what means and to what extent can these floods, so fatally affecting life and property, be prevented ?

With respect to the means of prevention. Referring to the plan I now submit: the dotted line shows the position of the tunnel I suggest being made to relieve the City proper from such floods, and runs, as you will observe, from the intersection of Stephen and Lonsdale-streets along Lonsdale-street to the Hospital corner, then bears north to Latrobe-street, and west to Batman's-swamp, making a total length of 109 chains.

This tunnel could be constructed without interfering with private property, and be at a sufficient depth beneath the level of the streets.

I have taken the levels at the various points, and I find that there is a fall of 47 feet between the surface level of Elizabeth-street at Latrobe-street and low water in the Yarra below the falls, and that the fall between a point at the Hospital corner of Swanston-street and low water level is 56·19 feet. There is also sufficient fall in Lonsdale-street, between Stephen-street and the Hospital corner.

It will thus be seen that there is a sufficient fall to give the most desirable inclination to the tunnel or underground sewer.

The material excavated in the construction of this tunnel could be used with great advantage in the reclamation of the low swampy ground lying between the railway and the western end of Latrobe, Jeffcott, Franklyn, and Dudley-streets, and the firm ground thus made would not only assist in the expense of constructing the tunnel, but would also improve the value of property in the immediate neighbourhood by converting what is at present an unsightly and unhealthy swamp, into ground capable of being drained and built upon.

The first 43 chains of the underground sewer would not require to be more than 12 feet in sectional area, and the remaining portion, namely, from Elizabeth-street to Batman's-swamp, from 36 to 44 feet in sectional area, according to the inclination it might be found desirable to give it.

These tunnels should be elliptical, or, as it is commonly called, egg-shaped, and should be constructed of hard burned bricks, moulded to suit the several curves, and set in Portland cement.

With respect to cost. This would depend upon the nature of the material to be excavated, but under any circumstances it would not cost the Government one-half the sum that is now, and has been for nine years, lying idle in the shape of cast-iron sewer covers on Batman's-swamp. Probably the best thing the Government could do with the said sewer covers would be to sell them to the ironfounders, and with the money thus obtained, execute the work now suggested, more especially as they will never be used for the purpose for which they were intended.

With respect to the extent that this plan would relieve Swanston, Elizabeth, and Flinders-streets; this may be accurately determined by reference to the foregoing tables, and the comparative areas that such tunnel would drain out of the areas at present drained by the open channels in Swanston, Elizabeth, and Flinders-streets.

Referring to the map you will perceive that the area tinted blue amounts to 530·35 acres, and that the area tinted red drains 248·2 acres. As the line of the proposed tunnels intersects those areas, as shown upon the plan, I have measured their collective area to the north of the tunnel, and find it to be 517·2 acres, being 115½ acres, or 28½ per cent., more than the entire area of the city proper (that is, between Spencer and Spring-streets, Latrobe and Flinders-streets). But, inasmuch as the whole of the water from the 517·2 acres passes through Swanston and Elizabeth-streets to the outlets A and B, the ratio of the difference between the quantities intercepted and the quantities discharged at the outlets A and B, will be considerably increased.

By referring to the area drained by the outlet B, namely, 248·2 acres, we find that the drainage of 145·6 acres would be intercepted by the tunnel, and that, consequently, the open channels in Swanston-streets would be relieved to the extent of nearly 59 per cent. of the waters that are now discharged by these channels during a storm.

The source of their supply would be bounded by Latrobe-street on the north, and the remaining 41 per cent. of the water would gradually accumulate on its way to the outlet. At Bourke-street, for instance, only 15 per cent. of the present quantity would be discharged during a storm, effectually preventing any overflow to increase the flood in Elizabeth-street.

Again, by referring to the area drained by the outlet at A, we find that the total acreage is 530·35, out of which we must subtract the area 33·35, drained by the same outlet, but unconnected with Elizabeth-street. Of this, the drainage of 371·65 acres would be intercepted by the proposed tunnel, and, consequently, the outlet would be relieved of nearly 75 per cent., or three-fourths of the storm-water and sewage, that is now discharged through its channel, or even during such a heavy rainfall as occurred on the 23rd September, 1856.

The result of this relief would be that at Lonsdale-street, instead of 83 per cent. of the total quantity of water discharged at the outlet being received into the open channel, there would be only about 8 per cent. At the Post Office, 14½ per cent, instead of 89½ per cent. At the Clarence Hotel, Collins-street, 20 per cent. in place of 95 per cent., and at the outlet itself, 25 per cent.

Irrespective of these great benefits that would accrue from this plan being carried into practice, there are others that are worthy of consideration, inasmuch as at the present time the city surveyor has to contend with these large bodies of water in the construction of the numerous crossings in the city.

If he makes these crossings too acute, or deep in their angles, they greatly interfere both with the comfort and safety of the passengers in vehicles crossing over them. If, on the other hand, they are made too obtuse or shallow, the crossings are subject to a deposit of the stones and sand, washed by the force of the current from the street, and the consequence is that he has no alternative left but to adopt a medium course, in which both evils are fully represented.

This, to a great extent, would be remedied by the plan now submitted, more particularly as the storm-water would never be in such volume as to remove the metal from the streets.

Many of the crossings of the city streets have been for the above reason most difficult to deal with. However, there are other open crossings of a very objectionable kind, situated in the principal thoroughfares, which might be entirely dispensed with by means of a combined cast and wrought-iron culvert, so constructed as to give the greatest strength and sectional area at the least depth below the surface level of the street, and at the same time to admit of easy access to any portion, so that the level of the street could be maintained.

I especially allude to an open channel crossing the main thoroughfare to Collingwood, from the Parliament House reserve to the Princess's Theatre ; to the open crossing at the east end of Collins-street, opposite the Treasury ; and the crossings in Collins-street at Queen-street, at William-street, and two at King-street. The four last crossings are upon the direct road of the vehicles running to and from the Victorian Railways, and are not only dangerous both to passengers and horses, but destructive to the vehicles.

A slight modification of the ingress end of such culverts would prevent their being choked, and any one in the habit of driving over these crossings can easily imagine the vast improvement such an alteration would make.

If the crossings to which I have now specially directed your attention had been where the streets are level or nearly so, I would not have recommended the adoption of a culvert instead of the open channel, but in each case I have alluded to the street not only has a considerable fall, but the quantity of water passing through these open channels is very limited indeed, as may be seen by reference to the plan.

In conclusion, I will briefly review the advantage to be derived by the adoption of the plan now submitted.

Swanston-street, at its intersection with Bourke-street, would be relieved of no less than 85 per cent. of the water which periodically renders this portion of the city impassable to foot passengers, to the great detriment of shop-keepers and the general public.

Elizabeth-street would derive still greater benefits. No overflow would take place from Swanston-street, and the quantity of water received by the channels would be diminished ; at Collins-street by 4-5ths, at Bourke-street by 5-6ths, and at Lonsdale-street by 9-10ths.

The photographs of Elizabeth-street (which I now submit) taken by Messrs. Perry & Co. during heavy rain storms, will give some idea of the vast body of water that passes down that street during a storm, but it is only by actual inspection of the scene after the flood has subsided that any conception can be formed of the destruction of property caused by such sudden inundations.

18, Collins-street East,
May 16th, 1864.

Art. XXX.—*On the Surface and Underground Drainage of the City of Melbourne.* By A. K. Smith, Esq., C.E. F.R.S.S.A.

[Abstract of paper, read 21st November, 1864.]

This paper on the Underground Drainage, is a companion one to that on the Surface Drainage of Melbourne, read 16th May, 1864.

The author, in forcible language, showed the great danger arising from want of proper sub-drains, and the consequece existence of fœtid pools, cesspits, and other abominations, under and around human habitations, and he also warned his auditors that fine streets and superficial external cleanliness, will not prevent the evil consequences of concealed nuisances. The author illustrated his statements from his own experience in Melbourne and elsewhere, and supported them with competent medical authority.

The author then proceeded to show at length—

That great facilities exist in Melbourne for efficient sewerage, owing to the abundant supply of water.

That the experience obtained during many years by the General Board of Health in England, has established the soundness of the principle of tubular drainage-pipes for sewerage of towns and cities, and the great economy and efficiency of them when in use.

That pipes varying from four inches up to twelve inches, have been and are successfully used for drainage in lieu of the old brick drains (nearly as many feet in diameter), to the great benefit of health, the more efficient removal of sewage, and a vastly decreased cost. That the amount requisite for removing deposit alone from the old drains of large size, forms a very large proportion of the first cost of the pipe-